## FREE-AIR CONDITIONS.

By L. T. SAMUELS, Meteorologist.

Free-air temperature departures for the month were, in general, positive, there being no negative departures greater than 1.0° C. (See Table 1.) Consistent with the mean surface temperatures as compared with their normals (see Chart III), the greater excess was observed in the interior of the country, Drexel reporting the largest departures followed by Broken Arrow and Groesbeck, respectively. The departures at each of these stations increased, generally, with altitude. The other three stations reported means varying only slightly from their averages from the surface to the highest levels.

Relative humidities were below the average at Broken Arrow, Drexel, and Ellendale, but slightly above at the other three stations. It is interesting to note that the monthly precipitation at these stations was either above or below normal as was the relative humidity above or below its average, with the exception of Royal Center, where the departures of the latter were slightly positive, yet the monthly precipitation was appreciably below the normal amount.

The vapor pressure, in general, followed the temperature as regards departures from the average. Irregularities in this respect were very probably due largely to the short period of record from which the averages have been computed.

Table 2 gives the free-air wind resultants and examination will show that as a rule where temperature departures are above the average the resultant winds have a more southerly component or at least a greater resultant velocity than normally.

As is to be expected winds become much lighter at this season of the year. Only a few observations during the month showed winds of 30 m. p. s. or more, all of these being single-theodolite pilot-balloon observations. These are given in the following table:

| Stations. | Date. | Direction. | Velocity. | Altitude. |
|---|---|---|---|---|
| | | | *M. p. s.* | *Meters.* |
| Ithaca, N. Y. | 12 | wnw | 32 | 1,100 |
| Lansing, Mich. | 10 | w | 38 | 4,000 |
| Camp Lewis, Wash. | 16 | w | 35 | 6,100 |
| Mather Field, Calif. | 19 | sw | 39 | 10,300 |
| Do. | 21 | sw | 34 | 5,900 |
| Mitchel Field, N. Y. | 12 | wnw | 33 | 3,200 |
| Royal Center, Ind. | 12 | wnw | 32 | 3,100 |

The high winds observed at Lansing on the 10th and at Ithaca, Mitchel Field and Royal Center on the 12th were an accompaniment of the cyclonic depression which caused numerous local disturbances and squalls, the most severe of which was the one occurring in the vicinity of New York City on the 11th.

Easterly winds at high altitudes become more frequent at this season and especially at the southern stations, where such winds were observed on about two-thirds of the total number of days in the month. No marked connection can always be associated with these winds and the surface-pressure distribution, but rather they seem to be the result of the transition from winter to summer conditions in the Northern Hemisphere. Such winds prevailed generally over the northern portion of the country from the 1st to the 4th and in the southern and southeastern part on the 5th and 6th. This seems significant in view of the fact that a strong, high-pressure area central over Montana on May 30, had gradually decreased in strength so that by June 4, six days later, it had moved only as far as the Mississippi Valley and had flattened so much that it lost its individuality and had become part of the greater high-pressure area centered over the Atlantic Ocean.

Similar winds were observed over the southern and eastern sections from the 20th to the 25th. The latitudinal surface-temperature gradients during this period were extremely small and therefore easterly winds aloft might be expected.

Conditions were favorable for reaching high altitudes with pilot balloons at Groesbeck, Tex. on the 14th and at Key West, Fla. on the 22d. Heights of 15,000 m. and 17,000 m. were reached at Groesbeck and Key West, respectively. The observation at Groesbeck was made with two theodolites and is therefore more trustworthy and of special interest since two-theodolite observations reaching this altitude are not numerous. Winds were light from the surface to the highest levels, the velocities never exceeding 9 m. p. s. The direction was southerly from the surface to 10,500 m., changing sharply to northerly and continuing to the highest level. The velocities at Key West were very light from the surface to 13,000 m. when they increased from about 3 m. p. s. to about 10 m. p. s. at 14,000 m. and 16 m. p. s. at 17,000 m. The direction was easterly from the surface to nearly 3,000 m., then changing to westerly through north and remaining so to 13,000 m., above which altitude it remained mostly north.

TABLE 1.—*Free air temperatures, relative humidities, and vapor pressures during June, 1922.*

TEMPERATURE (°C.).

| Altitude m. s. l. (*m.*) | Broken Arrow, Okla. (233*m.*) | | Drexel, Nebr. (396*m.*) | | Due West, S. C. (217*m.*) | | Ellendale, N. Dak. (444*m.*) | | Groesbeck, Tex. (141*m.*) | | Royal Center, Ind. (225*m.*) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean. | Departure from average. | Mean. | Departure from average. | Mean. | Departure from average. | Mean. | Departure from average. | Mean. | Departure from average. | Mean. | Departure from average. |
| Surface | 25.4 | +0.8 | 22.8 | +1.1 | 25.9 | −0.3 | 18.9 | −0.9 | 25.2 | −0.3 | 23.9 | +0.3 |
| 250 | 25.3 | +0.8 | ..... | ..... | 25.6 | −0.2 | ..... | ..... | 24.7 | +0.1 | 23.6 | +0.3 |
| 500 | 23.8 | +1.4 | 21.9 | +0.9 | 23.2 | +0.2 | 18.8 | −0.7 | 23.6 | +0.8 | 20.7 | +0.1 |
| 750 | 22.2 | +1.5 | 20.6 | +1.2 | 21.7 | +0.4 | 18.1 | +0.2 | 22.3 | +1.0 | 18.7 | +0.1 |
| 1,000 | 20.6 | +1.3 | 19.2 | +1.2 | 20.5 | +0.5 | 16.9 | +0.2 | 21.1 | +1.2 | 17.4 | +0.3 |
| 1,250 | 18.9 | +1.1 | 17.6 | +1.0 | 19.0 | +0.4 | 15.6 | 0.0 | 19.8 | +1.2 | 16.1 | +0.5 |
| 1,500 | 16.9 | +0.8 | 16.4 | +1.1 | 17.3 | +0.3 | 14.5 | +0.2 | 18.6 | +1.5 | 14.6 | +0.5 |
| 2,000 | 14.1 | +1.1 | 14.1 | +1.6 | 14.2 | +0.3 | 11.7 | +0.3 | 16.2 | +1.7 | 11.5 | +0.2 |
| 2,500 | 11.5 | +1.1 | 11.0 | +1.7 | 10.9 | +0.1 | 8.8 | +0.3 | 13.5 | +1.7 | 8.2 | −0.2 |
| 3,000 | 9.2 | +1.7 | 8.6 | +2.4 | 7.5 | −0.1 | 5.7 | +0.1 | 11.1 | +1.8 | 5.7 | 0.0 |
| 3,500 | 6.6 | +1.9 | 5.2 | +2.4 | 3.7 | −0.5 | 2.4 | −0.3 | 8.8 | +2.1 | 3.0 | −0.1 |
| 4,000 | 3.7 | +1.9 | 2.4 | +2.9 | 0.3 | −0.6 | −0.2 | −0.1 | 6.1 | +1.9 | 0.8 | −0.1 |
| 4,500 | 1.1 | +1.9 | ..... | ..... | −1.2 | −0.2 | −2.9 | +0.4 | 3.5 | +1.7 | ..... | ..... |

RELATIVE HUMIDITY (%).

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Surface | 73 | 0 | 61 | −4 | 66 | +3 | 73 | +1 | 79 | +4 | 59 | −2 |
| 250 | 73 | 0 | ..... | ..... | 66 | +2 | ..... | ..... | 78 | +3 | 60 | −1 |
| 500 | 71 | −2 | 63 | −4 | 67 | 0 | 71 | 0 | 77 | +2 | 63 | +1 |
| 750 | 70 | −3 | 59 | −6 | 66 | −1 | 64 | −5 | 75 | +1 | 65 | +1 |
| 1,000 | 70 | −3 | 60 | −5 | 66 | −1 | 61 | −6 | 71 | −1 | 66 | +1 |
| 1,250 | 70 | −3 | 60 | −4 | 66 | 0 | 60 | −5 | 68 | −2 | 67 | +1 |
| 1,500 | 68 | −4 | 57 | −5 | 66 | 0 | 57 | −6 | 63 | −4 | 68 | +2 |
| 2,000 | 59 | −9 | 53 | −6 | 66 | +1 | 54 | −7 | 58 | −3 | 65 | +2 |
| 2,500 | 48 | −10 | 52 | −6 | 67 | +3 | 53 | −6 | 59 | +2 | 60 | +6 |
| 3,000 | 40 | −13 | 49 | −8 | 67 | +4 | 53 | −2 | 55 | +5 | 55 | +7 |
| 3,600 | 40 | −12 | 57 | 0 | 68 | +4 | 54 | +1 | 52 | +5 | 46 | +5 |
| 4,000 | 39 | −9 | 39 | −18 | 56 | +4 | 50 | 0 | 46 | +1 | 26 | 0 |
| 4,500 | 29 | −9 | ..... | ..... | 32 | +4 | 50 | −8 | 47 | −2 | ..... | ..... |

VAPOR PRESSURE (*mb.*)

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Surface | 23.54 | +0.92 | 17.47 | −0.24 | 21.68 | +0.71 | 15.89 | −1.08 | 25.27 | +0.99 | 17.39 | −0.60 |
| 250 | 23.35 | +0.97 | ..... | ..... | 21.39 | +0.74 | ..... | ..... | 24.21 | +0.98 | 17.24 | −0.51 |
| 500 | 20.92 | +1.08 | 16.34 | −0.28 | 19.02 | +0.68 | 15.37 | −1.05 | 22.12 | +1.05 | 15.47 | −0.03 |
| 750 | 18.78 | +0.94 | 14.24 | −0.30 | 17.28 | +0.48 | 12.98 | −1.34 | 19.98 | +0.94 | 14.31 | +0.13 |
| 1,000 | 17.14 | +0.90 | 13.15 | −0.13 | 15.92 | +0.71 | 11.55 | −1.23 | 17.51 | +0.63 | 13.27 | +0.16 |
| 1,250 | 15.49 | +0.71 | 12.02 | +0.02 | 14.51 | +0.63 | 10.46 | −0.95 | 15.39 | +0.38 | 12.39 | +0.21 |
| 1,500 | 13.67 | +0.45 | 10.56 | −0.05 | 12.98 | +0.43 | 9.34 | −0.87 | 13.30 | +0.15 | 11.29 | +0.41 |
| 2,000 | 9.76 | −0.42 | 8.32 | −0.07 | 10.69 | +0.53 | 7.40 | −0.89 | 10.59 | +0.34 | 8.45 | +0.22 |
| 2,500 | 6.91 | −0.51 | 6.51 | −0.24 | 8.82 | +0.67 | 6.20 | −0.57 | 9.20 | +0.99 | 5.70 | +0.23 |
| 3,000 | 4.82 | −0.36 | 5.28 | −0.24 | 7.16 | +0.69 | 5.18 | −0.05 | 7.46 | +1.16 | 3.93 | +0.23 |
| 3,500 | 4.18 | +0.01 | 5.21 | +0.73 | 5.68 | +0.69 | 4.25 | 0.00 | 6.20 | +1.10 | 2.18 | +0.06 |
| 4,000 | 3.63 | +0.30 | 3.26 | −0.40 | 3.63 | +0.69 | 3.62 | +0.08 | 5.08 | +0.77 | 0.18 | −0.14 |
| 4,500 | 2.71 | +0.30 | ..... | ..... | 1.82 | +0.69 | 3.22 | −0.06 | 4.83 | +0.92 | ..... | ..... |

TABLE 2.—*Free-air resultant winds (m. p. s.) during June, 1922.*

| Altitude, m. s. l. (m.) | Broken Arrow, Okla. (233m.) | | | | Drexel, Nebr. (396m.) | | | | Due west, S. C. (217m.) | | | | Ellendale, N. Dak. (444m.) | | | | Groesbeck, Tex. (141m.) | | | | Royal Center, Ind. (225m.) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean. | | Average. | | Mean. | | Average. | | Mean. | | Average. | | Mean. | | Average. | | Mean. | | Average. | | Mean. | | Average. | |
| | Dir. | Vel. | Dir. | Vel. | Dir. | Vel. | Dir. | Vel. | Dir. | Vel. | Dir. | Vel. | Dir. | Vel. | Dir. | Vel. | Dir. | Vel. | Dir. | Vel. | Dir. | Vel. | Dir. | Vel. |
| Surface | S. 19° W. | 3.9 | S. 4° W. | 3.6 | S. 2° E. | 3.0 | S. 8° W. | 1.5 | S. 85° W. | 1.9 | N. 24° W. | 0.7 | N. 65° W. | 2.0 | S. 45° E. | 0.1 | S. 7° W. | 1.7 | S. 15° E. | 2.7 | N. 81° W. | 1.4 | S. 48° W. | 0.8 |
| 250 | S. 19° W. | 3.9 | S. 4° W. | 3.7 | | | | | S. 85° W. | 2.0 | N. 34° W. | 0.7 | | | | | S. 4° W. | 2.4 | S. 15° E. | 3.2 | N. 83° W. | 1.5 | S. 47° W. | 0.8 |
| 500 | S. 23° W. | 5.5 | S. 12° W. | 4.9 | S. 2° E. | 3.9 | S. 7° W. | 2.0 | S. 85° W. | 2.8 | N. 58° W. | 1.1 | N. 71° W. | 2.2 | S. 13° E. | 0.3 | S. 11° W. | 3.8 | S. 5° E. | 4.3 | S. 79° W. | 2.5 | S. 42° W. | 1.8 |
| 750 | S. 23° W. | 6.4 | S. 15° W. | 5.7 | S. 8° W. | 5.8 | S. 19° W. | 3.0 | S. 85° W. | 3.1 | N. 80° W. | 1.7 | N. 85° W. | 2.3 | S. 8° W. | 0.9 | S. 9° W. | 4.4 | S. 3° E. | 4.6 | S. 84° W. | 3.4 | S. 51° W. | 2.3 |
| 1,000 | S. 21° W. | 6.3 | S. 20° W. | 5.9 | S. 19° W. | 6.6 | S. 34° W. | 3.6 | N. 81° W. | 3.1 | N. 66° W. | 1.3 | N. 87° W | 2.6 | S 20° W. | 1.3 | S. 3° W. | 4.8 | S. | 4.9 | N. 84° W. | 4.6 | S. 71° W. | 2.9 |
| 1,250 | S. 21° W. | 6.4 | S. 23° W. | 6.2 | S. 24° W. | 6.7 | S. 45° W. | 4.0 | N. 71° W. | 3.4 | N. 58° W. | 1.4 | N. 89° W. | 3.1 | S. 50° W. | 2.0 | S. | 5.4 | S. 3° W. | 5.5 | N. 84° W. | 5.1 | S. 79° W. | 3.3 |
| 1,500 | S. 24° W. | 6.5 | S. 27° W. | 6.3 | S. 34° W. | 6.6 | S. 57° W. | 4.5 | N. 71° W. | 3.4 | N. 69° W. | 1.7 | S. 86° W. | 3.4 | S. 51° W. | 2.3 | S. 1° W. | 5.6 | S. 2° W. | 4.9 | N. 78° W. | 6.2 | N. 86° W. | 3.8 |
| 2,000 | S. 33° W. | 6.0 | S. 32° W. | 6.5 | S. 46° W. | 6.7 | S. 62° W. | 5.8 | N. 79° W. | 4.9 | N. 81° W. | 3.0 | W. | 5.0 | S. 63° W. | 3.5 | S. 1° E. | 6.1 | S. 2° W. | 4.7 | N. 83° W. | 11.1 | S. 89° W. | 5.9 |
| 2,500 | S. 31° W. | 5.4 | S. 29° W. | 6.5 | S. 52° W. | 9.3 | S. 72° W. | 6.7 | N. 83° W. | 6.2 | N. 81° W. | 4.0 | S. 87° W. | 8.4 | S. 72° W. | 5.3 | S. 7° W. | 6.4 | S. 9° W. | 4.5 | N. 82° W. | 13.1 | S. 88° W. | 8.1 |
| 3,000 | S. 35° W. | 5.2 | S. 19° W. | 6.7 | S. 53° W. | 11.6 | S. 78° W. | 8.5 | S. 88° W. | 7.0 | N. 86° W. | 5.4 | S. 80° W. | 12.2 | S. 78° W. | 7.2 | S. 4° W. | 7.2 | S. 15° W. | 5.0 | N. 79° W. | 16.0 | W. | 10.9 |
| 3,500 | S. 49° W. | 5.2 | S. 22° W. | 7.9 | S. 61° W. | 11.6 | S. 80° W. | 9.2 | S. 73° W. | 7.3 | S. 72° W. | 5.8 | S. 83° W. | 12.5 | S. 81° W. | 8.4 | S. 4° W. | 7.4 | S. 11° W. | 6.4 | N. 78° W. | 15.9 | N. 89° W. | 12.8 |
| 4,000 | S. 64° W. | 6.1 | S. 37° W. | 7.0 | N. 79° W. | 13.7 | N. 81° W. | 8.7 | S. 76° W. | 7.6 | S. 73° W. | 8.7 | N. 82° W. | 15.6 | N. 85° W. | 10.1 | S. 12° E. | 10.4 | S. 4° E. | 7.2 | N. 70° W. | 18.8 | S. 87° W. | 15.6 |
| 4,500 | N. 35° W. | 4.9 | | | | | | | N. 56° W. | 10.4 | | | N. 82° W. | 13.3 | N. 70° W. | 14.0 | S. 22° E. | 15.0 | S. 29° E. | 12.2 | | | | |
| 5,000 | | | | | | | | | N. 55° W. | 9.8 | | | N. 82° W. | 13.7 | N. 73° W. | 17.5 | | | | | | | | |

## THE WEATHER ELEMENTS.

By P. C. DAY, Climatologist and Chief of Division.

### PRESSURE AND WINDS.

As is usual in June, pressure diminished from the May values over the northeastern districts and from the Rocky Mountains westward, the decreases over the far Northwest being much greater than usual. In the central and northern interior districts where the pressure is usually distinctly less in June than in May, there was a rise of considerable importance, while in the southern districts from Texas and Oklahoma eastward, where the normal pressure in June is only slightly higher than in May, the increases during June were quite marked. As a result the pressure gradients for the different portions of the country were unusually small and the flattened system of isobars, common to the summer season, was more pronounced than usual.

While the cyclones and anticyclones formed in somewhat more rapid succession than usual, they were mainly of small dimensions and pursued rather indefinite courses.

The cyclones usually reached their greatest development over the more eastern districts, with a resultant excess of rainfall in those regions. On the other hand, the anticyclones moving southward from the Canadian Northwest attained their maximum intensity over the central valleys and Lake region, with accompanying dry weather in those localities.

For the month as a whole the atmospheric pressure was below normal over the northeastern districts and in parts of the far Northwest. In other districts the pressure was above normal and to a considerable degree in the Rocky Mountain and adjacent regions.

While the barometric gradients were weak the main slope was toward the north over the districts from the Rocky Mountains eastward, and the atmospheric circulation responded accordingly and southerly winds were general over all that region.

From the Rocky Mountains westward to the Pacific, there was some movement toward the low-pressure area over the far Southwest, but in most districts there was the usual diversity of directions, due mainly to varying topography.

No extensive areas had high winds on the same dates save about the 11th and 12th, when thunderstorms prevailed over much of the country from the Great Lakes and Ohio Valley eastward to the Atlantic coast. In some of the more eastern districts severe thunderstorms occurred on the afternoon of the 11th, attended by high winds, heavy rains, considerable loss of life, and much damage to property. A more detailed account of these storms will be found at the end of this section.

### TEMPERATURE.

No unusual heat or cold occurred during the month over extensive areas or periods, and the ranges from day to day were usually small.

The first week of the month was moderately cool over the interior valleys and southern States, and generally warm from the Ohio Valley eastward, along the northern border, and over most of the Plateau and Pacific Coast States, though it was cooler than normal in portions of California.

Conditions were partially reversed during the second week when there was a decided rise in temperature over all interior and eastern districts, and a general lowering along the northern border from the Great Lakes westward. Cool weather prevailed in the Great Valley of California, and it continued cool in the West Gulf section.

The third week of the month continued warm over the central valleys and Northwest, but a change to decidedly cooler overspread the Northeastern States, and temperatures below normal continued in western Texas, and extended into New Mexico and eastern Arizona.

The final week of the month continued warmer than normal over most districts from the Mississippi and Missouri Rivers westward, the warmth extending into the Southwest where temperatures below normal had persisted during much of the preceding portion of the month. This week continued warm over the Southern States, but like the preceding week it remained cooler than normal over the Northeast, the coolness extending into the Ohio Valley and Lake region.

For the month as a whole temperature averaged above normal over nearly all portions of the country, the only exceptions being small areas in central and western Texas and the adjoining portion of New Mexico, and locally in the northern portions of New York and Vermont.

At a few points the month as a whole was warmer than any preceding June, notably in western Montana, northern Idaho, and eastern Washington. In portions of the last-named State, June, 1922, is the first month since November, 1921, with average temperature above the normal.

No particular period of the month had notably high temperatures over large areas, but about the 14th to 15th